

A Multicenter Study to Improve Emergency Medicine Residents' Recognition of Intracranial Emergencies on Computed Tomography

From the Departments of Emergency Medicine,* Radiology,† and Neurosurgery,§ Carolinas Medical Center, Charlotte, NC; and the Department of Emergency Medicine,|| University of Virginia Health Sciences Center, Charlottesville, VA.

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Address for reprints: Jeffrey A Kline, MD, Department of Emergency Medicine, Carolinas Medical Center, Box 32861, Charlotte, NC 28232-2861, E-mail jkline@carolinas.org.

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Andrew D Perron, MD*
J Stephen Huff, MD||
Christopher G Ullrich, MD†
Michael D Heafner, MD§
Jeffrey A Kline, MD*

Study objective: Cranial computed tomography (CT) has assumed a critical role in the practice of emergency medicine for the evaluation of intracranial emergencies. Several recent studies have documented a deficiency in the emergency physician's ability to interpret these studies. The purpose of this study was to quantify the baseline ability of emergency medicine residents to interpret cranial CTs, and to test a novel method of cranial CT interpretation designed for the emergency physician in training.

Methods: A standardized pretest was administered to assess baseline ability to interpret CT scans. A standardized posttest was given 3 months after the course. Each test consisted of 12 CT scans with a short accompanying history. All scans were validated by 3 expert reviewers for difficulty and diagnosis. A 2-hour course based on the mnemonic "Blood Can Be Very Bad" was then administered. "Blood" reminds the examiner to search for blood, "Can" prompts the examiner to identify 4 key cisterns, "Be" denotes the need to examine the brain, "Very" prompts a review of the 4 ventricles, and finally "Bad" reminds the examiner to evaluate the bones of the cranium.

Results: Eighty-three residents at 5 institutions were initially examined. The mean percentage correct before the course was 60% (95% confidence interval [CI] 58%-64%) on the standardized pretest. At retesting 3 months after the course, the accuracy rate increased to 78% (n=61, 95% CI 75%-81%, $P<.001$ paired t test).

Conclusion: Emergency medicine residents are deficient in their ability to interpret cranial CT scans. A novel educational course was demonstrated to significantly improve this ability.

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INTRODUCTION

The cranial computed tomograph (CT) has assumed a critical role in the practice of emergency medicine for the evaluation of intracranial emergencies. Numerous previous studies have revealed a deficiency in the ability of emergency physicians to interpret head CTs.¹⁻⁷ Nonetheless, in many hospitals, emergency physicians must interpret head CTs initially without assistance from other specialists.⁸

Despite the immediate importance for emergency physicians to recognize intracranial emergencies on head CT, no formalized educational process has been created and validated to meet this need. In contrast, medical trainees are taught to systematically examine and interpret ECGs (eg, rate, rhythm, axis) to identify significant pathologic conditions that may not be readily apparent. With a concept of developing a similar systematic approach to interpretation of head CTs in mind, we created a mnemonic and associated educational course. In a pilot study at the Carolinas Medical Center, we found that this educational course significantly improved the accuracy rate of CT interpretation by emergency medicine residents.⁹

The objectives for this project were 2-fold. The first objective was to conduct a multicenter examination of the ability of emergency medicine residents to identify intracranial emergencies on cranial CT. The second objective was to create, implement, and test the validity of an educational intervention to improve this ability. The goal of this edu-

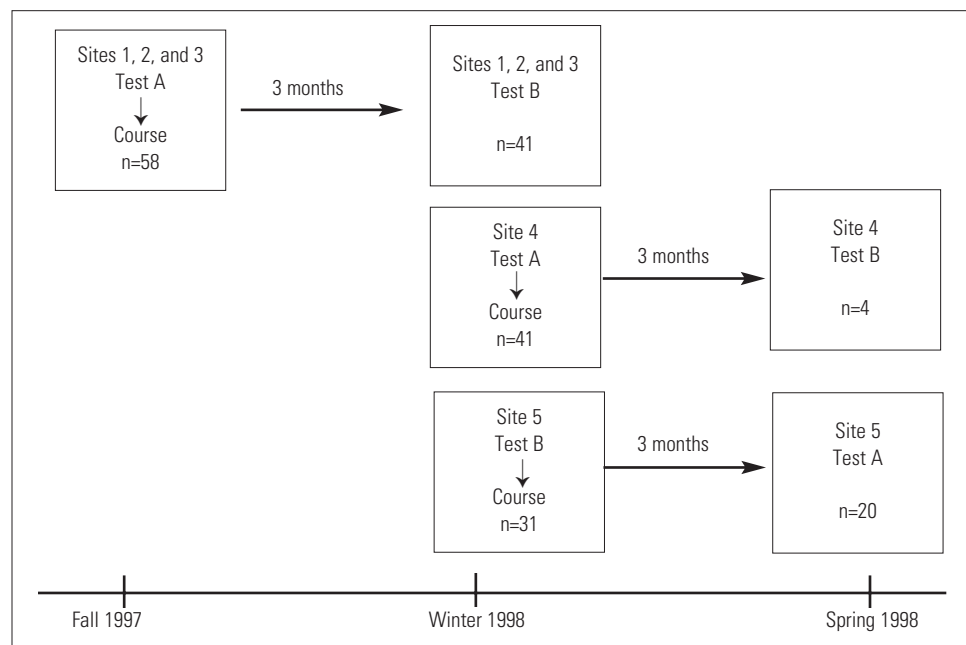
cational intervention was to teach a logical, simple, and generalizable approach to interpreting head CTs. The proposed method used a mnemonic that prompted a systematic search for the anatomic loci of most intracranial emergencies. A mnemonic was chosen because of its demonstrated ability to improve knowledge retention.^{10,11}

METHODS

Emergency medicine residents from 5 different training programs participated in this study. An institutional review board exemption was obtained. All study subjects were in training at the postgraduate year (PGY) I, II, or III level. The 5 centers included Carolinas Medical Center, Christiana Hospital (Delaware), Richland Memorial Hospital (South Carolina), University of North Carolina—Chapel Hill, and University of Virginia. At Carolinas Medical Center, only the PGY-I class was studied, as the PGY-II and PGY-III classes had participated in the pilot study and thus had prior exposure to the course and mnemonic.⁹ Hereafter, we refer to participating institutions by randomly assigned numerals 1 to 5 to maintain anonymity regarding test results. The study used a parallel, crossover design (Figure 1). Subjects at sites 1, 2, and 3 were administered Test A as a pretest in October 1997. In February 1998, subjects at site 4 were administered Test A as a pretest and subjects at site 5 were administered Test B as a pretest, to validate both tests for difficulty and to control for non-

Figure 1.

Overview of study design. Residents from Sites 1, 2, and 3 were administered Test 1 followed by the 2-hour educational course in the fall of 1997. After 3 months, residents were retested (winter 1998). As a control measure to ensure equivalent test difficulty and to account for non-specific education during standard residency training, residents at Site 4 were given Test A and residents at Site 5 were given Test B in the winter of 1998. Both sites subsequently received the educational course with posttesting 3 months later.



specific learning that might occur during the academic year. All subjects received the 2-hour educational course immediately after the pretest. As Figure 1 demonstrates, subjects were retested at least 3 months after the educational course (posttest). Subjects at sites 1, 2, 3, and 4 received Test B as the posttest. Subjects at site 5 received Test A as the posttest. Three months was chosen as the lag time for retesting to attenuate immediate recall.¹²

A CT scan library was collected by the authors. Fifty CT scans were chosen to reflect the diagnoses that are commonly encountered by emergency physicians. These diagnoses included the normal scan, intracerebral and basal ganglia hemorrhage, subarachnoid hemorrhage, diffuse brain swelling, mass effect from tumor, subdural hematoma, epidural hematoma, and brainstem and cerebral infarction. The library included 15 normal scans, and each test included 5 of these normal CT scans. The reason for this large number of normal CT scans was 2-fold. First, the results on the majority of scans ordered from the emergency department are negative, and therefore it follows that the practitioner must gain confidence in detecting a head CT with negative findings for significant pathology. The second reason was that in a pilot study, we found that the most frequently missed diagnosis was the normal CT scan.⁹ Before testing, all 50 CT scans were independently validated for content, diagnosis, and difficulty (on a scale of 1 to 3) by an emergency physician/neurologist (JSH), a

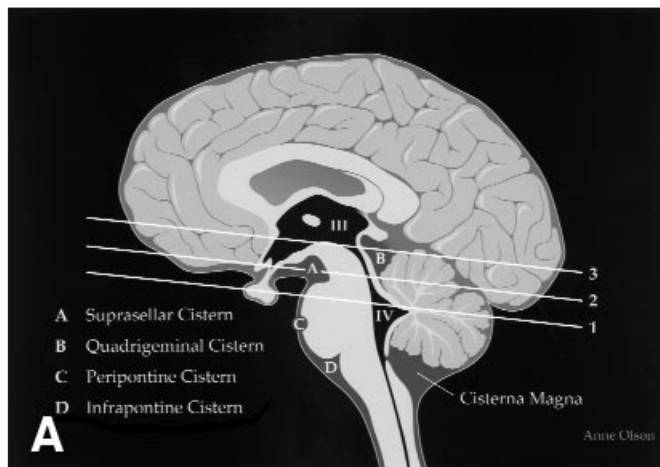
neuroradiologist (CU), and a neurosurgeon (MH). All experts were board-certified in their respective specialties. Only scans with complete agreement by all 3 reviewers ($\kappa=1$) were selected, and scans of equal difficulty and of similar diagnostic composition were chosen for both tests (Appendix 1 and 2).

Test A and Test B each consisted of 12 cranial CT scans with a short accompanying history. In each case, the test subject was given a 2-panel, full-sheet, non-contrast-enhanced head CT. Participants were given access to light boxes to assist in CT scan viewing. There were no duplicate scans on the pretest and posttest. One hour was allotted to complete the test. All tests were scored in a blinded fashion, but the subject retained the ability to obtain his or her individual score by means of a number code mechanism.

The educational intervention consisted of 2 1-hour lectures, each given by the authors (AP and JK). The first hour was dedicated to reviewing normal neuroanatomy with images of anatomic brain slices, schematic drawings, and corresponding CT scan images. The purpose of this review was to familiarize the emergency physician with the key normal anatomic structures demonstrated on head CT. Special attention was given to identification of subarachnoid cisterns, location of vasculature, and normal brain density. A medical illustrationist helped develop images to demonstrate key features of the CT scan, as well

Figure 2.

A, Illustration of the 3 key levels of CT examination as taught in the course. Level 1 is through the 14th ventricle, the midbrain, and the circumsephenoidal cistern. Level 2 is through the cerebellum, the aqueduct of Sylvius, the suprasellar cistern, and the forebrain. Level 3 is through the quadrigeminal cistern, the third ventricle, and the frontal lobes. Corresponding axial images were produced and used in the educational course. **B**, Three-dimensional depiction of the suprasellar cistern as used in the course. The image demonstrates the relationship of the suprasellar cistern to the midbrain, cerebellum, and pituitary.



as create 3-dimensional illustrations demonstrating the relationship of important anatomic structures to each other (Figure 2). The course was structured to correspond with the mnemonic “Blood Can Be Very Bad” (Figure 3). In this segment of the course participants were taught that “**Blood**” should prompt review of the locations of the major blood supply to the brain, with special attention to those areas where hemorrhage is most likely to occur in pathologic conditions. Particular notice was drawn to the location of the circle of Willis in the suprasellar cistern. “**Can**” should prompt the examiner to look at 4 key **cisterns** (the quadrigeminal, the circummesencephalic, the suprasellar, and the sylvian). During the course, their locations and normal appearances were emphasized. The **brain** parenchyma (“**Be**” in the mnemonic) was reviewed to demonstrate the normal appearance of gray-white differentiation, sulcal patterns, and basal ganglia location. Limitations of posterior-fossa imaging with CT technique were discussed. The **ventricles** (“**Very**” in the mnemonic) were reviewed for the normal location, morphology, and range of size for the lateral, third, and fourth ventricles. The normal effect of aging on ventricular size was also discussed. Finally, for the **bony skull** (“**Bad**” in the mnemonic) normal anatomy was examined, focusing on location of sutures, air cells, and sinuses.

In summary, the goals for this first hour were 2-fold. One was to give subjects confidence in their ability to identify the normal structures present on head CTs. The second was to familiarize them with the mnemonic, which was used in the second hour of the didactic session to help them recognize intracranial emergencies.

The second hour of the course covered the most important pathologic conditions the emergency physician must identify. The mnemonic was again the basis for review of the head CT. The goal was to teach the emergency physician to run through the entire mnemonic on each head CT to prompt systematic review and identification of significant intracranial emergencies. Subjects were taught that identification of 1 intracranial emergency (eg, subarachnoid hemorrhage) does not exclude the presence of another (eg, acute hydrocephalus). For this reason it was stressed that the complete mnemonic must be used on each scan.

In using the mnemonic, extravascular blood was the first pathologic process to identify on the head CT (“**Blood**” in the mnemonic). Multiple examples of subarachnoid, epidural, subdural, intraparenchymal (deep bleed versus cortical bleed), and intraventricular hemorrhage were demonstrated. Acute sequelae that are associated with each condition were reviewed here (eg, lateral or transten-

torial herniation from epidural hematoma). “**Can**,” which should prompt review of the cisterns, was used to demonstrate 2 critical findings in head CTs, namely subarachnoid hemorrhage and increased intracranial pressure. Special attention was drawn to the normal dark, star-shape of the suprasellar cistern. This normal appearance was contrasted to its appearance when blood-stained from aneurysmal rupture or when effaced from increased intracranial pressure. Multiple examples of each of these processes were illustrated. “**Be**,” which should prompt review of brain parenchyma, was used to help subjects recognize the important findings of early ischemic stroke, such as loss of gray-white differentiation, asymmetry of gyral pattern, and the insular ribbon sign. Ultra-early ischemic CT changes were not emphasized in the course, as even their definition remains in flux.⁷ Traumatic pathologic condition such as contusion, and nontraumatic conditions, such as tumor, abscess, and atrophy were also

Figure 3.

Association of each word in the mnemonic Blood Can Be Very Bad with corresponding emergency.

Blood Can Be Very Bad

•**Blood:** Acute blood is bright white on CT. Types include:

- EDH (lens-shaped)
- SDH (sickle-shaped)
- Intraparenchymal (especially basal ganglia)
- Intraventricular (watch for hydrocephalus)
- SAH (blood in cisterns)

•**Cisterns (Can):** CSF collections jacketing the brain. Look for blood in cisterns

- (SAH), and effacement (increased ICP). 4 key cisterns:
 - Circummesencephalic (ring around midbrain)
 - Suprasellar (star-shaped) Circle of Willis
 - Quadrigeminal (W-shaped)
 - Sylvian (between temporal and frontal lobes)

•**Brain (Be):** Look for:

- Symmetry
- Gray-white differentiation
- Shift
- Hyper/hypodensity
- Pneumocephalus

•**Ventricles (Very):** CSF produced in lateral ventricles (back-to-back commas)

- III ventricle (slit-shaped) → aqueduct of Sylvius → IV ventricle (helmet-shaped). Approximately 20 mL/h. Look for:
 - Effacement
 - Shift
 - Blood

•**Bone (Bad):** Note soft tissue swelling. Look for blood in sinuses/mastoid air cells, widened sutures.

EDS, Epidural hematoma; **SDH**, subdural hemorrhage; **SAH**, subarachnoid hemorrhage; **CSF**, cerebrospinal fluid; **ICP**, intracranial pressure.

reviewed. Examples of “contrast effect” on blood-brain barrier destruction were also demonstrated. “Very,” which prompted review of the ventricular system, was used as an anatomic reference to demonstrate ventricular shift and hydrocephalus in its various permutations. Particular attention was drawn to several methods that help differentiate acute hydrocephalus from nonurgent causes of brain atrophy. For examples, transependymal flow, indicative of acute hydrocephalus, was described and shown. “Bad” should prompt review of the bony skull. Accordingly, the course demonstrated conditions such as skull fracture, air-fluid levels in the mastoid air cells, and sinus pathology. Examples of basilar skull fracture were particularly emphasized.

Participants were given no written handout during the educational course, nor were they given any follow-up materials or specific teaching during the 3-month washout period.

Two statistical comparisons were performed. Baseline scores for Test A were compared with baseline scores for Test B with an unpaired *t* test. Mean baseline scores also were compared with mean postintervention scores using a paired *t* test and 95% confidence interval (CI) for difference in means.

RESULTS

A total of 83 residents were tested at the 5 sites over a 6-month period. PGY training level was distributed as follows among the PGY years: PGY-I 39%, PGY-II 27%, and PGY-III 34%.

The mean score for all 83 subjects who were examined before any educational intervention was 60% (95% CI 58%-64%). Fifty-two examinees completed Test A before the educational intervention. The mean score was 60% correct interpretation (95% CI 56%-64%). By site, the scores were as follows: Site 1 (n=9) 66%, Site 2 (n=20) 58%, Site 3 (n=13) 58%, and Site 4 (n=10) 60%. Baseline scores did not differ significantly by PGY year (Figure 4). A total of 31 examinees at site 5 took Test B before the educational intervention. The mean score was 61% correct (95% CI 56%-66%). The difference in scores between Test A (60%) and Test B (61%) before the educational intervention was not significant (*P*=.65, unpaired *t* test). This finding helps show that the tests were not significantly different with respect to test difficulty.

The mean score for all 61 tests taken after intervention was 78% (95% CI 75%-81%). Forty-two examinees took Test B as the posttest (mean score 78%, 95% CI 74%-82%). By site, the scores were as follows: Site 1 (n=9) 78%, Site 2

Figure 4.

Precourse and postcourse mean raw scores by postgraduate year (PGY) (±95% CI). Solid bars indicate test scores before educational course; open bars indicate test scores after educational course (maximum possible correct =12).

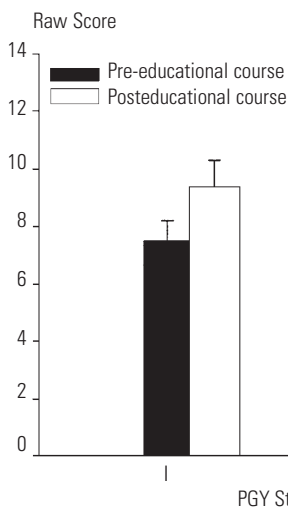
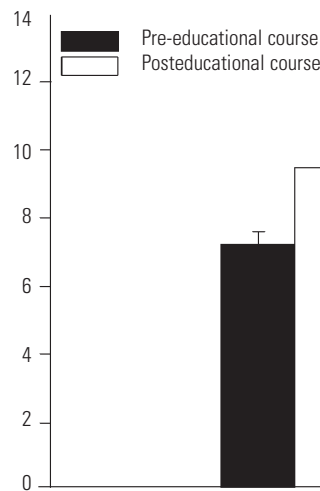


Figure 5.

Summary of raw test scores, where “pre” and “post” refer to the educational course. Solid bars indicate test scores before educational course; open bars indicate test scores after educational course. **P*<.001 for mean of posteducational course versus pre-educational course, paired *t* test.



(n=20) 79%, Site 3 (n=9) 79%, and Site 4 (n=4) 71%. Twenty-one examinees at site 5 took Test A as the posttest (mean score 79%, 95% CI 74%-84%). When the preintervention mean (60%) was compared with the postintervention mean (78%), the change in scores was significant by paired *t* test ($P<.001$) (Figure 5), as well as by the 95% CI for the difference in means (95% CI for difference of 18% =13.2%-22.8%).

Subjects at all 3 PGY training levels were able to significantly improve their ability to recognize intracranial emergencies (Figure 4). When examined by diagnosis, residents improved their score for all intracranial emergencies except ischemic stroke, epidural hematoma, and diffuse swelling (Figure 6).

To help determine the educational significance of this course, a questionnaire was administered after the posttest, 3 months after the educational course. At that time, 93% of those who answered could recall and write the mnemonic; 86% reported using the mnemonic as taught in the course, and 97% believed that their skill in interpreting CTs was better after the course. On a visual analog scale from 1 to 10 (1=not helpful and 10=very helpful), the course rating averaged 8.1. All residents (100%) stated they would recommend the course to a colleague.

DISCUSSION

To the practicing emergency physician, the importance of the head CT is self-evident. At the authors' institution, 3% of all ED patients undergo cranial CT examination. At many institutions, the emergency physician must interpret the CT primarily.^{7,8} Despite the importance for emergency physicians to be trained to recognize intracranial emergencies on head CT, no formalized educational process has thus far been created or validated to meet this need. This project was conceived to develop a systematic, simple, and lasting method for the emergency medicine practitioner to interpret cranial CT scans.

The present multicenter study, conducted at 5 emergency medicine training programs, demonstrates that emergency medicine residents correctly identified intracranial emergencies with only 60% accuracy. However, by implementing a 2-hour didactic session based on the mnemonic *Blood Can Be Very Bad*, we demonstrated that interpretation accuracy improved from 60% to 78% 3 months after the educational intervention.

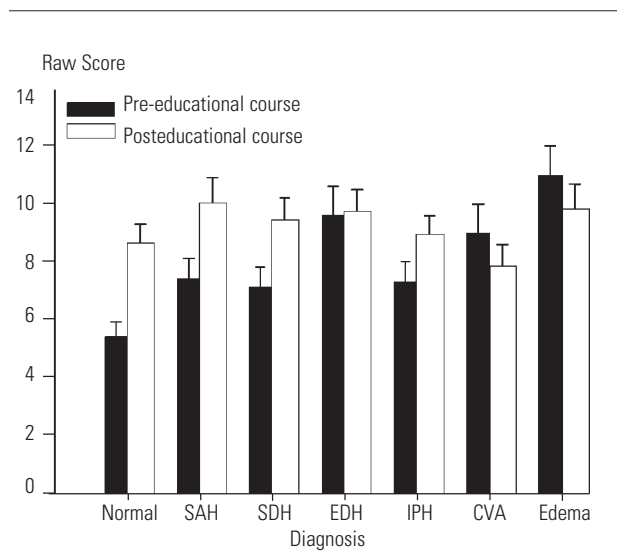
Previous studies have revealed a deficiency in the ability of emergency physicians to interpret head CTs. Alfaro et al¹ found a 39% discordance rate between radiologists and emergency physicians in head CT evaluation. In the same

study, clinically significant misinterpretations were found in 24% of 555 scans. In a recent study published by Levitt et al⁶ that specifically examined cranial CT interpretation by attending emergency physicians, the authors found a 61% accuracy rate. A "clinically significant" misinterpretation rate of 24% was also noted in that study. In a retrospective chart review study that specifically examined emergency physicians' ability to interpret cranial CTs, Gratton et al² reported only a 3.2% discordance rate between emergency physicians and radiologists. However, their study was of limited benefit to the clinician because they did not consider false-positive interpretations.

Alfaro et al¹ conclude their discussion with the recommendation that "more formal education in head CT interpretation [should] be incorporated into emergency medicine residencies and continuing medical education programs. Focused education may help to minimize misinterpretations." We likewise recognized this need for focused education in residency training. We chose a mnemonic as our learning tool as this technique has been shown to be an excellent way to organize and remember information.^{10,11} The use of an educational intervention to improve the clinician's medical skills has been used frequently with good results. Studies by Lossing and Groetzch,¹³ Gurwitz et al¹⁴

Figure 6.

Test scores by individual diagnosis, pretest versus posttest. Solid bars indicate test scores before educational course; open bars indicate test scores after educational course. SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage; EDH, epidural hemorrhage; IPH, intraparenchymal hemorrhage; CVA, cerebrovascular accident.



Bibbie et al,¹⁵ and Anderson et al¹⁶ have all shown that physician behavior and skill can be modified by teaching interventions.

In a recently published study, by Levitt et al,⁶ an attempt was made to determine whether a brief educational session could improve CT interpretation skills of attending emergency physicians. In their study, a 1-hour educational session was used to demonstrate normal and abnormal CT scans. That course covered many of the same topics as our educational course. Their carefully executed study showed that a 1-hour course improved overall concordance between attending emergency physicians and a covering radiologist. Our findings support the conclusions of their study, but the present report provides several significant differences in study design. First, we studied residents in a multicenter fashion, using original and reproducible teaching methods and testing material. Our goal was to validate the course as a generalizable method of education to be included in residency training programs. Second, our study was designed to test pure radiographic interpretation skills with bias from "clinical intuition" relatively controlled: each examinee had the same short case vignettes that did not clearly indicate any single diagnosis (Appendix 1 and 2). This was in contrast to the study by Levitt et al, where participants were managing patients and may therefore have had a more detailed history, as well as physical examination clues to assist them in making a diagnosis. It cannot be certain whether participants had access to other information that might have helped them interpret the CT scans. Third, we allowed for a 3-month washout period between the intervention and the retesting process. This was to ensure that short-term recall was not a factor, and that the participants had in fact assimilated the mnemonic and method of CT review into their practice. The Levitt group began the posteducational phase of their study 10 days after their course. A fourth difference between the studies was that our diagnoses were agreed on by 3 different expert practitioners, rather than a single radiologist.

Our study was designed to help control for nonspecific learning that might occur during residency training. We tested 2 control groups (Sites 4 and 5) 3 months after the educational course was given to Sites 1, 2, and 3. If a significant amount of nonspecific learning had occurred during the course of the year, one would expect their mean scores to be higher than those who took the test earlier in the year. As the data show, this was not the case. Mean scores for site 4 and 5 pretests (administered in February 1998) were not significantly different than those for sites 1, 2, and 3 (administered in October 1997).

Although our course significantly improved the ability of residents to recognize most intracranial emergencies, there were 2 areas where notable exceptions were found. Despite emphasizing the CT changes found with ischemic stroke and increased intracranial pressure during the course, we did not improve residents' ability to recognize these pathologic changes on CT (Figure 6). Levitt et al⁶ also found ischemic stroke the most missed diagnosis in their study. In a recent study by Schriger et al⁷ that examined the ability of emergency physicians to recognize the earliest signs of cerebral infarction in reference to suitability for thrombolytic therapy, they similarly found a marked deficiency in practicing emergency physicians' ability to identify these changes (67% accuracy). The authors concluded that emergency physicians do not possess the skills to make this diagnosis based on CT scan interpretation. Our results tend to agree with that conclusion.

LIMITATIONS AND FUTURE QUESTIONS

First, we can only comment on the correct interpretation rate of cranial CT scans. The clinical significance and resultant management errors of misinterpretation are not discernible from this study. Previous studies have cited a lower rate of "clinically significant misinterpretations" and even lower rates of inappropriate initial management. The purpose of this study was only to identify the emergency physician's ability to diagnose intracranial emergencies on the basis of cranial CTs.

Second, a selection bias could have been introduced because not all subjects at all sites were retested. Inasmuch as participation in the course and posttesting was voluntary, we may have selected only those residents most interested in cranial CT interpretation and thus, motivated to do well. Related to this is the fact that some motivated residents may have sought additional education in CT interpretation after the pretest. This would also add selection bias if these particular residents were overrepresented on the posttest.

An obvious future question is whether this mnemonic and course will impart to the emergency physician a lasting ability to accurately interpret cranial CTs, and more importantly make appropriate initial interventions based on that interpretation. We used 3 months as a washout period between the course and testing. Retesting at an even later time may not have resulted in as large of a change in scores.

This study raises the larger question of what the emergency physician's role should be in the interpretation of emergency cranial CT scans. This study was not intended

to credential emergency physicians to interpret cranial CTs without the assistance of the radiologist. It is intended only as a starting point to help educate emergency physicians, especially those who must make life-altering decisions without immediate radiology backup.

Cranial CT interpretation is a complex and often critical diagnostic tool used by the emergency physician. No formalized educational process has previously been created or validated to improve the emergency physician's ability to recognize intracranial emergencies. Using the mnemonic "Blood Can Be Very Bad" and a 2-hour didactic session, we demonstrated significant improvement in the recognition of intracranial emergencies by emergency physicians 3 months after instruction. This mnemonic and the course provide a simple, durable approach to cranial CT interpretation by the emergency physician.

We thank Dr. Ronald Follmer at Carolinas Medical Center, Dr Robert Vissers at University of North Carolina at Chapel Hill, Dr Thomas Sweeny at Christiana Care Hospital, and Dr Joseph Myslinski at Richland Memorial Hospital, without whom this study would not have been possible.

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Appendix 1

Test A questions with multiple-choice answers. Correct diagnosis in parentheses.

- Case 1:** 14 y/o male in MVC. Now unresponsive. (Epidural hematoma)
- Case 2:** 8 y/o female, s/p seizure. Now postictal, with nonfocal neurologic exam. (Normal)
- Case 3:** 43 y/o male with severe headache. Temperature of 99.2. (Normal)
- Case 4:** 39 y/o female with severe headache and nausea. Nonfocal neurologic exam. (Diffuse brain swelling)
- Case 5:** 54 y/o intoxicated male with very unsteady gait; c/o mild headache. (Cerebellar CVA)
- Case 6:** 28 y/o male, s/p assault, found unresponsive at the bottom of a flight of stairs. (Subdural hematoma)
- Case 7:** 15 y/o male, s/p MVC, now c/o headache and nausea. Vomits once. Nonfocal neurologic exam. (Normal)
- Case 8:** 65 y/o male with right-sided weakness, aphasia. (Cerebral stroke)
- Case 9:** 63 y/o female, s/p single-vehicle MVC with decreased responsiveness. Seizes x2 in the ED. (Mass with edema)
- Case 10:** 77 y/o female with seizure, now postictal. Nonfocal neurologic exam. (Subarachnoid hemorrhage)
- Case 11:** 22 y/o female with the "worst headache of my life." Nonfocal neurologic exam. (Normal)
- Case 12:** 58 y/o male alcoholic with dysarthria. Refuses to cooperate with neurologic exam. (Normal)

Multiple-choice answers:

- | | |
|-------------------------------|-----------------------------|
| ___ Normal scan | ___ Subarachnoid hemorrhage |
| ___ Epidural hematoma | ___ Subdural hematoma |
| ___ Diffuse cerebral swelling | ___ Lacunar CVA |
| ___ Cerebellar CVA | ___ Brainstem CVA |
| ___ Cerebral CVA | ___ Hydrocephalus |
| ___ Mass with edema/shift | ___ Pneumocephalus |
| ___ Skull fracture | |

y/o, Year old; **MVC**, motor vehicle crash; **CVA**, cerebrovascular accident; **s/p**, status-post; **c/o**, complains of.

Appendix 2

Test B questions with multiple choice answers. Correct diagnosis in parentheses.

- Case 1:** 83 y/o female with right-sided weakness. (Intraparenchymal hemorrhage)
- Case 2:** 86 y/o female with intermittent right-hand tingling. H/O EtOH abuse. Bilateral tremor on exam. (Normal)
- Case 3:** 12 y/o female skied into a tree. Now decerebrate posturing. (Epidural hematoma)
- Case 4:** 77 y/o female with severe headaches, nausea, and memory loss for 2 months. Nonfocal neurologic exam. (Normal)
- Case 5:** 3 y/o female found unconscious in the basement. (Normal)
- Case 6:** 40 y/o male w/hx of chronic migraines. C/o severe headache. NI exam. (Subarachnoid hemorrhage)
- Case 7:** 70 y/o female found on floor of apartment. Now hypothermic and unresponsive. (Cerebral CVA)
- Case 8:** 70 y/o female found unresponsive in bed at nursing home. Intubated by paramedics. (Brainstem CVA)
- Case 9:** 34 y/o female, c/o excruciating right-sided headache with nausea/vomiting. No previous episodes. Can't cooperate with neuro exam. (Normal)
- Case 10:** 67 y/o male found seizing in parking lot, now flaccid and intubated. (Subdural hematoma)
- Case 11:** 18 y/o female in high-speed MVC. Now flaccid and intubated. (Diffuse swelling)
- Case 12:** 48 y/o male in high-speed MVC. Now unresponsive, with a nonfocal neurologic exam. (Normal)

Multiple-choice answers:

- | | |
|-------------------------------|---------------------------------|
| ___ Normal scan | ___ Subarachnoid hemorrhage |
| ___ Lacunar CVA | ___ Subdural hematoma |
| ___ Diffuse cerebral swelling | ___ Cerebral CVA |
| ___ Cerebellar CVA | ___ Brainstem CVA |
| ___ Epidural hematoma | ___ Hydrocephalus |
| ___ Mass with edema/shift | ___ Pneumocephalus |
| ___ Skull fracture | ___ Intraparenchymal hemorrhage |

H/O, history of; **EtOH**, ethyl alcohol; **w/hx**, with history; **ni**, normal; *see Appendix 1 for other abbreviations.*